assessing a patient's ability to use vestibular information to control balance, this test provides a multifaceted assessment of motor responses to challenges to balance. It thus provides an important evaluation of a patient's functional balance capacity that can be used to direct rehabilitative programs.

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Improved Diagnosis of Acoustic Neuroma With Auditory Brain-Stem Evoked Responses and Gadolinium-Enhanced MRI

THE MOST FREQUENT REASON for a clinical suspicion of acoustic neuroma is a unilateral or asymmetric sensorineural hearing loss, although patients may present with persistent vertigo or other neurologic symptoms. As only about 5% of patients undergoing evaluation for an acoustic neuroma will ultimately be found to have a tumor, an efficient and economic diagnostic tree is essential. Following a standard audiometric evaluation, which identifies patients "at risk," auditory brain-stem evoked responses (ABRs) are obtained when there is sufficient residual high-frequency hearing. The ABR is a computer-averaged recording of the changes induced in the electroencephalogram due to sound stimulation. A series of peaks that correspond to different levels in the auditory central nervous system is generated. The results of the ABR are abnormal in more than 95% of patients with proven acoustic tumors. When the latency of the most prominent wave (V) is symmetric and within normal limits, an acoustic neuroma is improbable. The rare false-negative findings generally occur in patients whose acoustic tumors have arisen in the cerebellopontine angle, rather than within the internal auditory canal. False-positive ABR studies are common and indicate the need for an imaging study.

The definitive diagnosis of acoustic neuroma requires an anatomic visualization of the cerebellopontine angle and the internal auditory canal. Contrast-enhanced computed tomographic (CT) scanning reliably visualizes larger tumors but detects less than 50% of tumors that are less than 2 cm in diameter. As the ability to preserve the function of the auditory and facial nerves is highly dependent on tumor size, detecting tumors when they are small is a primary goal in acoustic tumor diagnosis. Recently magnetic resonance imaging (MRI) has become the diagnostic imaging technique of choice in the evaluation of acoustic neuromas, and it has numerous advantages over CT. It provides a noninvasive means of detecting very small tumors that previously would have required gas-contrast CT. False-negative studies appear to be exceedingly rare when a proper slice thickness and imaging technique are used. A few false-positive MRIs have been noted, especially in patients with large internal auditory canals. Within a wide canal that is partially compartmentalized by arachnoid webs, restricted cerebrospinal fluid circulation may lead to an increased protein concentration in the trapped fluid. This returns a bright signal on T2-weighted images. Until recently, adjudicating such equivocal MRI results required gas-contrast CT scans. The introduction of the MRI contrast agent, gadolinium DTPA, however, has rendered this unnecessary. This paramagnetic metal ion, which was recently approved by the Food and Drug Administration, induces a notable increase in the signal intensity of an acoustic neuroma. It has been used in more than 10,000 patients worldwide without significant morbidity. Aside from reducing the incidence of false-positive studies, gadolinium contrast MRI has, in our series, revealed several small tumors that were entirely inapparent on nonenhanced MRI scans. Gadolinium-enhanced MRI also appears to be useful in cases of possible recurrence where differentiating tumor from scar tissue or implanted muscle plug may be difficult using other techniques.

Magnetic resonance imaging also displays surgically important information that was not available on earlier studies. On MRI, the lateral extent of tumor penetration in the internal auditory canal can be evaluated. This both assists the surgeon in planning the operative route (translabyrinthine, retrosigmoid, or middle fossa) and in differentiating an acoustic neuroma from other cerebellopontine angle neoplasms such as meningiomas, which usually do not possess an intracanalicular component. Another advantage of MRI is its ability to visualize intrinsic brain-stem disease such as multiple sclerosis that may mimic the clinical presentation of an acoustic neuroma. In summary, MRI with gadolinium contrast has virtually rendered obsolete all other imaging methods used in diagnosing and characterizing acoustic neuroma. Computed tomography is reserved for those patients known to have metallic implants (MRI hazardous) and in those 5% to 10% of patients who, because of claustrophobia, are unable to tolerate insertion into the magnet.

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Implantable Hearing Aids

ONE OF THE NEW AND EXCITING ADVANCES in otolaryngology and head and neck surgery is the development of hearing devices designed to be implanted in the ear of patients with mixed or conductive hearing loss. These devices have some similarities to cochlear implants used for profound hearing loss, but the indications are different.

At this time two basic types exist. In one type a magnet-containing bone screw is inserted into the mastoid bone behind the ear. A modified hearing aid containing a microphone, amplifier, battery, and an output coil is worn externally with the coil lying over the implanted magnet. Sound amplified by the hearing aid goes to the coil, which energizes the magnet to vibrate the skull so that the patient hears by bone conduction. The ear canal is left open, avoiding problems of drainage and recurrent infection with a tight-fitting ear mold. Sound quality is exceptionally good. This device appears to be an ideal solution for patients with bilateral canal atresia and inoperable conductive hearing loss.

In the other type, which is still in the experimental stage, a small magnet is placed in the middle ear on the stapes at the time of the middle ear operation. The vibrating element may be contained in a middle ear prosthesis and is externally energized using electromagnetic induction through an external hearing aid with coil. In this version the ossicles are directly vibrated rather than the mastoid bone, a much more efficient system. If the operation fails to totally correct the hearing loss, the implant component can be used to produce amplification. Again, the ear canal is open, minimizing the problems of a tight ear mold. In the simplest version, a magnet is encapsulated in a middle ear prosthesis so that it can be energized by an external coil to vibrate the ossicles. The sound is particularly clear and preferred compared with the sound of conventional hearing aids. Whereas this type of device is still experimental, it is expected to be available soon. The magnetic bone screw is available and is being used for the treatment of certain types of conductive and mixed hearing loss. In the future it may well be possible that these implant instruments will also be used for neurosensory loss because of the improved sound clarity they provide.

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Conserving Hearing in Acoustic Tumor Operations

OF THE 2,500 PATIENTS with acoustic tumors removed at the Otologic Medical Group, Los Angeles, only 5% were candidates for hearing preservation operations. Unfortunately, the tumor is usually too large at diagnosis for this procedure. In selected cases, however, hearing conservation may be possible using the middle fossa or retrosigmoid approach.

The two most important factors to be considered are the size of the tumor and the level of preoperative hearing. Secondary factors are the preoperative results of brain-stem evoked response audiometry (BERA) and electronystagmography (ENG).

The limit of the tumor size for the middle fossa approach is 1.5 cm and for the retrosigmoid approach is 1.5 to 2 cm. We also prefer patients with good preoperative hearing as candidates for hearing preservation operations. Our guidelines are a speech reception threshold of at least 30 dB and a speech discrimination of 70%.

In our series of 106 patients with removal of middle fossa acoustic tumors, patients with tumors arising from the superior vestibular nerve had a better hearing outcome than those with tumors from the inferior vestibular nerve. This may reflect a greater involvement of the cochlear nerve or cochlear blood supply by tumors developing in the inferior compartment of the internal auditory canal. Preoperative ENG is helpful to predict tumor origin. When such testing showed hypoactive calorics, indicating a superior vestibular nerve tumor, hearing was preserved in 64% of patients. Only 48% of patients had their hearing preserved when the preoperative calorics were normal.

There is a trend toward a better rate of hearing preservation with a relatively normal preoperative results of BERA. For patients with a preoperative intra-aural wave V latency difference of 0.4 milliseconds or less, hearing was preserved in 78%. For greater latency differences, the hearing preservation rate dropped to 58%. With no response on BERA, postoperative measurable hearing remained in only 50% of patients.

In summary, the ideal candidate for hearing preservation during acoustic tumor removal should have good preoperative hearing, a small tumor, near-normal preoperative results on BERA, and hypoactive calorics on preoperative ENG. The needs of the patient should also be considered, however, and these criteria should be tailored to each patient.

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Botulinum Toxin for Treatment of Spastic Dysphonia

SPASTIC DYSPHONIA is a voice disorder of unclear etiology yet clinically distinguishable by strained, staccato, effortful speech with voice arrests. The vocal abnormality results from spasm or hyperadduction of true and false vocal cords. It is believed to be a focal dystonia, similar to essential blepharospasm, yet the underlying pathophysiology is poorly understood. It has been proposed to be a heterogeneous disorder including different subtypes—psychogenic, neurologic, and idiopathic—or part of a generalized neurologic disorder.

Diagnosing spastic dysphonia involves subjectively evaluating a patient's speech. Although videostroboscopy can be helpful in identifying a laryngeal tremor, standard laryngoscopy, acoustic analysis, glottography, and electromyography are often not helpful. A lack of understanding of the pathophysiology of this disorder has resulted in a myriad of treatments including speech therapy, psychotherapy, biofeedback, muscle relaxants, tranquilizers, and anticonvulsant therapy. The results from these types of therapy, however, have been disappointing. In 1976 recurrent laryngeal nerve section was introduced, which has been the single most effective treatment of refractory spastic dysphonia. The initial results were excellent, but recent long-term reports have found the results to be temporary with a return of symptoms despite unilateral vocal cord paralysis.

Botulinum toxin has been used to temporarily paralyze selected muscle groups to relieve spasm in such conditions as blepharospasm, torticollis, and, more recently, spastic dysphonia. Botulinum toxin A is one of the neurotoxins produced by *Clostridium botulinum*. It interferes with presyn-